An integrated method for estimating compensations for environmental services of forests

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Abstract: The values of non-marketable forest products have largely been ignored, which made the conservation of the natural resources increasingly more economically difficult. Based on the previous studies, compensation subsidy for the values of non-marketable forest products was computed with a method of compensation coefficient that combines the Engel Coefficient and Logistic Curve. The method was applied in Changbai Mountain area. The total value of the compensation subsidy in 1999 was supposed to 637.93 Yuan·hm^{-2}, of which 70% would be paid directly to the local stakeholders and is much higher than the compensation subsidy previously computed (75Yuan·hm^{-2}·year^{-1}). It is currently impossible for the central government to bear all the costs and investment of natural forest protection. A practical solution is that the local government should invest in forest and put the compensation subsidy into the current revenue.
Keywords: Compensation subsidy; Engel Coefficient; Logistic Curve; Opportunity Cost
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Introduction

In the first four decades of the People's Republic of China's history (between 1950 and 1990), high demands for timbers led to overexploitation of forests, which contributed to ecological disasters, such as soil erosion, desertification, grassland degradation, and biodiversity declines. It was estimated that annual direct economic losses caused by various forms of natural disasters could be as high as ￥200 billion Yuan in China (Xu 2002). It is ecologically and economically important to take active measures to protect natural resources in China, particularly in the upper and middle reaches of major rivers. The Natural Forest Protection Program (NFPP) initiated in 1998 is helping correct a number of mistakes but faces with difficulties of long-term implementation, including the targeting and level of compensation payments, distributions of compensation payments, as well as evaluations of program impacts. Furthermore, current standard of subsidy, about 75 Yuan·hm^{-2}·year^{-1}, is too low for the various forest areas according to the huge ecological services the forests provided. At present, when forestry communities become economically more difficult, it becomes more urgent than before to straight out the relationships between societal benefits and forest producers' responsibilities for improving public payment schemes in China. In the last a few years, some scientists have made progress and put their studies into practice in a few countries, such as the "ecological value added tax" in most of Brazilian states (Monzoni 2002). The calculation is based on the Biodiversity Conservation Coefficient (CCB) that is defined as a relation between the surface area of the conservation unit (or other protected area), characterized as satisfactory in physical quality (or in process of being recuperated), and the surface area of the municipality, corrected by a conservation factor associated with different management categories (Monzoni 2002). Gamez's studies (2002) in Costa Rica showed that the opportunity costs of forgoing land use were considered as compensation criteria, while monetary estimates of the actual environmental services and protection were also included as basis for the compensation payment.

As a pioneer program, China's Ecological Compensation for forests was first implemented on Qingcheng Mountain of Chengdu Municipality in Sichuan Province (Xu 2002). Although this approach was in fact more appropriate and feasible than others, the past experiences showed that the standard of subsidies was not appropriate as the opportunity costs of forgoing economic management of forests were not taken into account. Therefore, realizing forests' ecological benefits via market instruments remains at its explorative stage for the most part. In China, many scientists have explored this field (Zhang 1997; Wu 2002; Wen 2001a, b; Tian 2002). Our study is aimed to integrate different theories and practices overcoming the current policy's shortcomings for providing an effective method according to the current situation of China.

Study areas and methods

Study areas

The study is carried out in Changbai Mountain, which is situated in the east of Jilin Province, Northeast China. Forest on Changbai Mountain is well-protected and is the cradle of Three Main River (Songhua River Yalu River and Tumen River). In the past, the values of non-marketable forest products have largely been ignored. As a consequence, the society received free services of non-marketable forest products without being aware of them. Meanwhile, forest managers including forest farmers had for a long time to bear the costs of producing and providing such non-marketable forest services. Because of this misconception, forest entities did not receive any compensation for the provision of ecological services. In recent years, the demands for ecological services have increased and many restrictions have been imposed on the management of commodity forests. The forest pro-

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ducers cannot afford the high cost for providing the public with social and ecological services as they are required to invest more in forest management and protection. This economic crisis would lead to an overall and widespread degradation of the ecological environment. In order to avoid this, compensation subsidy needs to be adopted.

Methods

The Pigouvian Tax from the classic welfare economics was a representation of state intervention via taxation. It is doubly effective: the state gets revenue, and the environment is improved because the taxes discourage harmful externalities. Based on the definition, we refer to the U.S Conservation Service Program (Xu 2002), which is composed of seven factors, to set up an appropriate method for conserving forests according to the present situation in the study area.

The determination of compensation standards needs to consider at least two factors: the quality of forest stands and forest ecological benefit. Because of diverse conditions in different areas, the breakdown of this subsidy shall vary with regions and economic conditions, resource endowment and management status. According to the studies of Wu *et al.* (2001), forest ecological benefit could be valued based on forest characteristics and its surrounding environment. Here we focus on the willingness to pay.

Compensation coefficient is used to weigh the current standard of subsidy people's willingness to pay. Numerical values of the coefficient were described by the Engel Coefficient and Logistic Curve, which can be used in economic analysis to show the actual payment of beneficiary for forest services. Engel Coefficient is often used to describe the extent of development for a society (Table 1), which shows the average behaviour of consumption expenditure does change fairly regularly with income. The higher level of development status, the smaller the Engel Coefficient, meaning that if society is rich enough, people there may devoted less proportion of total spending to food as income increase. The relationship can be described as this: Engel Coefficient is expenditure on food divided by total income. In economics, the Logistic Curve is often used to demonstrate the change of the economic profit in certain social working conditions (Cao 1998; Huang 2002), which is used to show the trend of ecological payment with the change of the social development (Fig. 1). The Logistic Curve's formula is expressed as:

$$y = \frac{k}{1 + a e^{-bt}} \tag{1}$$

where, y is compensation coefficient, $y \in (0,1)$; k is maximum coefficient of y ($y=1$); a, b *is* constants, and t is time.

Table 1. Corresponding relations between Engel Coefficient and development extend for a society

Development status	Poverty	Lower level	Well-to-do level	Rich	Extremely rich
Engel Coefficient	>60%	60-50%	50-30%	30-20%	<20%
1/Engel Coefficient	<1.67	1.67-2	2-3.3	3.3-5	>5

Notes: the values were calculated by the Samuelson and Nordhuas (2002)

When we integrate all these factors to calculate the coefficient, the compensation subsidy Q(t) is calculated as follows:

Q(t)=the value of the forest ecological benefit (t) × compensation coefficient (t) (2)

Furthermore, the benefit analysis of country-level institutions and operators should be considered. Some scientists suggested that local compensation standard should be set by the participation of local people in a bidding system (Xu 2002), opportunity cost of forgoing the economic management of the forest is taken as the minimum standard for compensation comparing to the living standard at local region, which determines the possibility of this policy. If the compensation subsidy is higher than the opportunity cost, this policy is worth doing. As to the eco-tour values, secondary product of forest and timber values are taken into count. We leave out other values of forest's ecological functions in order to simply the calculation:

$$OC = EV + NTFP + TV \tag{3}$$

where, OC is the opportunity costs; EV is eco-tour values; TV is timber values; and $NTFP$ is non-timber forests product values.

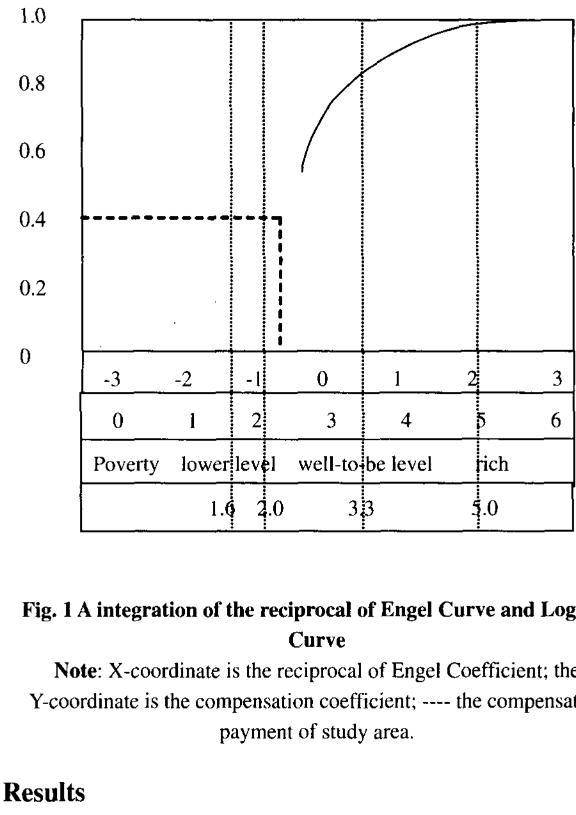

Fig. 1 A integration of the reciprocal of Engel Curve and Logistic Curve

Note: X-coordinate is the reciprocal of Engel Coefficient; the Y-coordinate is the compensation coefficient; ---- the compensation payment of study area.

Results

Compensation payment

The Engel Coefficient provides a baseline for quantifying the compensation coefficient. Its computation in this paper considers the weight in the local region. According to statistic data in 2001 (Statistical department of Yanbian 2002) and the definition of Engel Coefficient, the Engel Coefficients of county and downtown are 2.558 and 4.198, respectively. By assigning weight to human populations in the county and downtown, the Engel Coefficient is (1440/4752) × 13.23%+(563/1132) × 86.77% = 0.47164.

Based on Fig. 2, we get the reciprocal of Engel Coefficient as 2.12 and the corresponding compensation coefficient as 0.412. According to Wu (2001), the total value of forest ecological services of forests on Changbai Mountain in 1999 is 3.042×10^{8} Yuan. Therefore, with the use of equation (2), we can derive the compensation subsidy in 1999 to be 1.253×10^{8} Yuan. The total forest area is 196 465 hm^2 (Xue 1997), therefore, the compensation subsidy is 637.93 Yuan·hm^{-2}.

Cost-benefit analysis

The above compensation is the theoretic value. In fact, of the funds provided, 70% was allocated directly to county-level organizations and operators, with the remaining 30% allocated on a project basis, which will be used for specific projects, such as pesticide projects, etc. (Liu 2002). Therefore, the actual funds be given to the operator is only 70% of calculated value, that is 446.55 Yuan per hectare. Opportunity cost of forgoing the economic management of the forest is high if restrictions are harder in order to protect the forest. The opportunity costs of the forest comprise the eco-tour, the non-timber forests product as well as timbers, which count about 4%, 3%, and 7% of the total service values, respectively, according to the results of Wu (1999). The total opportunity cost is 47.32 million Yuan or 278.9Yuan per hectare, by using equation (3). The result suggests that the method we proposed is worth doing. This method can limit disafforestation in the key areas and compensate the stakeholders' losses as well.

From the Table 2 we can find that A_1, A_2, and A_3 are the indifferent curves, representing one goods substitution for the other, all are equally desirable. If the local institutions get enough compensation payment (OE), the need for the timber (OB) will be lower than the previous benefit (OB) with the same utility of the goods. Consequently, the forest can be well protected and provided appropriate incentives for ecologically oriented forest management.

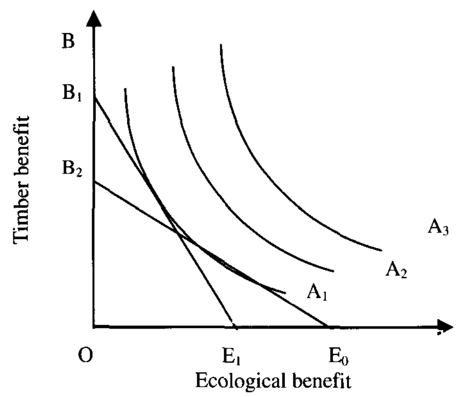

Fig. 2 Indifferent Curve

Note: the table comes from Wen (2001b). A_1, A_2, and A_3 are the indifferent curves, OE_1 OB_1 is the current compensation payment and timber benefit we got. OE_0 OB_2 are our calculated values.

Discussion and conclusion

It is important to effectively solve the external diseconomy forests produce for the whole ecosystem function. Under the background of the fact that various countries pay close attentions to ecological environments in the world, setting up and implementing the system of the economic compensation to forest service is a new action in China and has meaningful outcomes. On the basis of studying on the services of forests, we suggest the method of ecological tax, which is called economic compensation, should be adopted by the public. The ecological tax can not only consider the ecological importance of each particular forest ecosystem but also take other social factors, such as the living standard, as an important compensation criterion. The results calculated this way has reasonable rationality and reality. However, the lack of data, particularly the data for the study area, the compensation criterion we drawn up need further tests through practice.

The existing standard of subsidy, about ￥ 75 Yuan·hm^{-2}·$year^{-1}$, was too low for many forests. Therefore, an effective compensation criterion still needs to be emphasized. But our estimation is somewhat high because the study area is the typical forest ecosystem, which has higher values of forest ecosystem service than those of others. Of course, the development level of the local area can also affect the estimation. Nevertheless, the total compensation payment is not a fixed price, varying with the economic levels.

The lack of adequate and reliable capital input has been the major obstacle to the development of ecological forests in China and it would be impossible for the central government to bear all the costs and investment of natural forest protection. Along with this, another major trend is the decrease in the share of state budgetary allocation in ecological forests. This suggests that besides the funds provided by the government, the specific funds, with sources of funding clearly linked to those receiving the benefits, would be more effective in compensating environmental-service providers than general funds, such as the compensation between upstream and downstream regions. Except for these two sources of the compensation funds, the consumers of forests are the third payer for it. All the consumers that use the forest directly or indirectly should pay for it in order to sustain the development of forests. We can put this charge into the forest goods, such as an extra charge from hotels in Costa Rica (CCIECD), to compensate the values of forests. Whether this suggestion is reasonable in China, and how to combine it into the current tax system as well as how much it would pay for are further difficult problems we will confront.

In this study, the analysis of cost-benefit is simple and it is important to further investigate the significant socioeconomic impacts for the range of stakeholders, including forest enterprises, local governments depend on the forestry sector for revenue, collective forest owners, and rural households.

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